DOCUMENT RESUME

ED 324 666 CS 010 288

AUTHOR Clausing, Carolyn S.; Schmitt, Dorren R.
TITLE Does Computer Screen Color Affect Reading Rate?
PUB DATE May 90
NOTE 20p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (New Orleans, LA, November 1990).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Analysis of Covariance; Cloze Procedure; Comparative Analysis; Grade 8; Junior High Schools; *Reading Comprehension; *Reading Rate; Reading Research; *Video Display Terminals
IDENTIFIERS *Legibility; Text Design; Text Factors

ABSTRACT

A study investigated differences in reading rate and comprehension scores of 8th grade students on a cloze reading exercise involving the reading of a cloze passage from 10 different modes of text presentation (8 different computer screen formats and 2 different paper formats). Subjects, 300 students in computer literacy classes from 7 schools in a large suburban school system, randomly placed into 1 of 10 treatment groups, read a passage with 50 missing words and wrote the missing words on an answer sheet. The time taken to complete the exercise was considered to be the subject's reading rate. The passages were scored to determine the subject's comprehension measure. Results indicated no significant differences in reading rate or comprehension for any of the 10 groups; thus the ability of individuals to comprehend text does not appear to be impaired by the decreased legibility of computer screens. (Four tables of data are included; 24 references are attached.) (RS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

Does Computer Screen Color Affect Reading Rate?

ED324666

Carolyn S. Clausing

Jefferson Parish Public School System

and

Dorren R. Schmitt

University of New Orleans 70148

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Dorren R. Schmitt

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

CS010288

Paper presented at the Annual Meeting of the Mid-south Educational Research Association, New Orleans, LA, November 1990.

ABSTRACT

In the past century, much research has addressed the legibility of text in print. Sanford (1888), Griffing and Franz (1896) and Tinker (1963) have contributed to this body of knowledge. Studies have been performed to determine the best length of line, color, and line spacing. These researchers have found that reading rate is adversely affected by the legibility of the electronic screen text. But these studies were based adult reading rates.

The only reading from a computer screen study involving junior high school students was by Feldmann and Fish (1987). The major focus of the study, was to determine if reading from the computer screen affected junior high school students' comprehension. Additionally, the study questioned whether reading rates were affected by the legibility of electronic screen text.

The present study investigated differences in reading rate and comprehension scores of eighth grade students on a cloze reading exercise involving the reading of a cloze passage from ten different modes text of presentation. The study was designed to compare reading rate and comprehension scores of junior high students reading from paper copy or computer screen. In addition, the study was designed to determine optimal electronic screen text presentation modes, involving line length, background and foreground color, and contrast ratio.

Two one-way ANCOVAs were used to analyze the data. One ANCOVA analyzed reading rate while the other analyzed the comprehension scores. The ANCOVA results indicated that there were no statistically significant differences in reading rate or comprehension score for any of the ten groups.

The findings of no differences in reading speed from electronic screens to paper conflicts with most of the findings on adult reading rate research (Gould & Grischkowsky, 1984, 1986; Hathaway, 1984). Reasons accounting for the difference in findings may be: (a) the reading of the adult subjects was superior to the eighth grade students; (b) the nature of the reading materials, proofreading as opposed to a cloze passage; and (c) the focus on groups of students rather than the individualized treatment of adults. This would suggest that reading level might be a factor affecting reading rate from electronic screens or paper.

The finding of no difference in comprehension was consistent with previous studies. Thus, the ability of adults or eighth grade students, to comprehend text does not appear to be impaired by the decreased legibility of computer screens. Although the reading rate of adults seems to be effected by the legibility of computer screens, eighth grade students' reading rates do not appear to be adversely affected. Thus, a reader would reduce his reading rate in order to maintain comprehension.

Does Computer Screen Color Effect Reading Rate?

Computers and electronic screens have become integral parts of American society. Office workers, engineers, scientists, designers, writers, accountants, and many others spend long hours in front of electronic screens. Often, the amount of text presented on the screen is considerable.

Student computer usage in schools has increased rapidly. There are approximately 52 thousand computers, for instructional purposes, in approximately 48 percent of the public school districts (Becker, 1986; Niman, 1987). Many states now require students to take computer literacy classes. Because of the great influx of computers into schools, the time has come to assess the impact of the electronic screen on reading performance in a school setting.

Reading Performance

There is considerable evidence that electronic screens negatively impact reading performance when presenting text. People read more slowly from electronic screens (Gould, Alfaro, Barnes, Finn, Grischkowsky, & Minuto, 1987; Gould, Alfaro, Finn, Haupt, & Minuto, IN PRESS; Gould & Grischkowsky, 1984, 1986; Hansen, Doring, & Whitlock, 1978; Hathaway, 1984; Kruk & Muter, 1984; Muter, Latremouille, Treurniet, & Beam, 1982). A few studies (Gould & Grischkousky, 1984, 1986; Muter et al., 1982) have indicated that reading rate decreased by as much as 20 to 30 percent when the

computer-based electronic screen was the mode of text presentation.

Text Legibility

Text legibility research defines those features that affect electronic screen text legibility. According to Tinker (1963), a formost scholar in printed text legibility, reading speed is critically dependent upon text legibility. Legibility, according to Tinker (1963, p. 8),

> ...deals with the coordination of those typographical factors inherent in letters and other symbols, words, and connected textual material which affect ease and speed of reading.

The factors associated with legibility include: the size of the print, the shape of the font, the illumination of the reading environment, the color and quality of the paper, and the distance between letters and between lines of print. Daniel (1985, p. 4) in refering to electronic screens stated, "the term 'legibility' denotes how specific physical characteristics of a display effect [sic] visual fatigue, reading speed, and ultimately comprehension".

Studies of printed text legibility date back to Sanford (1888) and Griffing and Franz (1896). Huey (1968) summarized many text legibility studies and made recommendations about the optimum text presentation. The conclusions from Huey (1968) included: (a) the type should be no smaller than 1.5 mm or 6 points, (b) the optimal line length should be between 90 and 100 mm or about 60 characters per line, (c) the best color paper is white, and (d) the use of

double spaced text or additional leading, that is more space between lines of print improves legibility. Tinker (1963) also found that the curvature of printed mateial, like that found in books with narrow "gutters", reduced reading speed.

Finally, Tinker (1963) investigated color combinations of print and paper. Tinker (1963) observed that black print on a white backgrount, "yielded the most rapid reading" (p. 146). But, other color combinations were almost as effective: green on white, blue on white, and black on yellow. All othe color combinations retarded speed of reading considerably.

Computer Screen Legibility

During the 1970s and 1980s, researchers investigated electronic screen legibility. Hoover (1977) compared reading performance with single and double spaced computer text. No statistically significant differences were found in reading rate although the subjects indicated that they had more trouble reading single spaced text (Hoover, 1977).

Kruk and Muter (1984) performed a series of three experiments to determine if it was feasibile to read continuous text from an electronic screen. They concluded that it was feasible, but that reading speed was slowed by approximately 25 percent. They later concluded that this speed deficit could be decreased to 10.9 percent through the use of double spacing.

Other studies investigated reading rate using printed text and computer screen text. Hansen et al. (1978) had college students

take a reading test on computer-based electronic screens and on paper. They found that students read more slowly on computer screens. Kak (1981) performed a similar study with a standardized, timed reading test. Kak's results indicated no statistically significant differences in reading scores and only a four percent slower reading speed for students taking the test on computer. Kak (1981) concluded "that legibility criteria may be excessively strict when applied to tasks involving reading of connected prose text" (p. 139).

Switchenko (1984) conducted a study involving adult subjects in a comprehension reading task. Subjects read two short articles which differed in degree of difficulty. Subject then answered comprehension questions. Switchenko found no significant differences in reading speed or comprehension scores from computer or paper. Switchenko (1984) argued that studies which found a difference in reading speed did not have adequate and proper experimental controls. Gould et al. (IN PRESS) concluded that people can proofread as fast from computer displays as long as the fonts in the two media appear similar.

Thus, there is some controversity whether or not reading speed is decreased on a computer screen. An important note that needs to be made is that all of these studies used adults. To this point, there are only two studies (Feldmann & Fish, 1987a, 1987b) involving school aged children assessing reading rate and comprehension differences with paper and computer screens.

Statement of the Problem

A survey of available literature on electronic screen legibility uncovered only one related study involving junior high age students (Feldmann & Fish, 1987b). The students in the study were high ability eighth grade students and no statistically significant difference in reading comprehension was found between paper and computer-based electronic screen media. Other electronic screen legibility studies were generally conducted in the workplace with small samples of convenient adult subjects.

Other questions also need to be addressed. If indeed, junior high students do read more slowly from electronic screens as adults seem to, are there easily controlled factors which might improve the legibility of print on electronic screens?

The present study investigated if there were differences in reading rate scores of eighth grade junior high students on a cloze reading comprehension task involving the reading of text from several different modes of presentation. The following modes of presentation were studies:

1. An electronic screen with white text on black background utilizing a line length of 60 characters.
2. An electronic screen with white text on a black background utilizing a line length of 80 characters.
3. An electronic screen with black text on white background utiliging a line length of 60 characters.
4. An electronic screen with black text on white background utiliging a line length of 80 characters.

5. An electronic screen with black text on a light blue background utilizing a line length of 60 characters.

6. An electronic screen with black text on a light blue background utilizing a line length of 80 characters.

7. An electronic screen with white text on a light blue background utilizing a line length of 60 characters.

8. An electronic screen with white text on a light blue background utilizing a line length of 80 characters.

9. White paper with black IBM PC Junior matching font printed on a dot matrix printer with a line lenth of 60 characters.

10. White paper with blac Courier 10 font printed on a laser printer with a line length of 60 characters.

The two research questions addressed in this study were:

1. Is there a difference in eighth grade students' reading rate on a reading comprehension task among groups performing the task using several different modes of presentation?

2. Is there a difference in eighth grade student's comprehension score on the reading comprehension task among groups performing the task using several different modes of presentation?

Method

Three hundred junior high school students in computer literacy classes, in seven schools from a large suburban school system, were involved in this study. The subjects were randomly placed into one of 10 treatment groups. The subjects completed a cloze reading passage from the De Santi Cloze Reading Inventory. The first and last sentences of the passage were left intact, but every fifth word in the main body of the passage was deleted. The passage had fifty missing words. The students read the passage, decided which words were missing, and wrote these words on an answer sheet. The time, in minutes and seconds, taken to complete the exercise was measured by the investigator using a stop watch. The time to complete the passage was used as the subject's reading rate. The passages were subsquently scored, and this score was used as the subject's comprehension measure. Subjects all read the same passage, but the passage was presented in one of the 10 different text presentation modes. This design allowed comparisons to be made among the means of the various treatment groups.

In order to allow the subjects to "...overcome the effects of unfamiliarity with the cloze procedure..." (De Santi, 1986, p. 7), one day before the data collection subjects participated in a 20 minute practice session. The practice session also enabled the subjects to practice using the arrow keys on the computer to scroll text forward and backward on the screen. Actual collection of data took one class period. Administration of the cloze passage took approximately 30 to 35 minutes. Collection of materials took

approximately 5 minutes with no more than 45 to 50 minutes needed for the conduct of the study. Class periods in the schools participating in the study were 55 minutes in length.

The students were told that their reading would be timed, but that reading time was not as important as being accurate. Students were asked to raise their hand when they completed the exercise. A stop watch was used to measure the time it took students to complete the cloze passage. When all students had completed the exercise, all materials were collected.

For the purposes of this study, The De Santi Cloze Reading Inventory was converted to the eight different computer presentation modes. Additionally, two different paper presentations modes were created. The first paper version (group 9) was created using the ChiWriter (1988) software package to create a font similar to the IBM PC Junior screen. The second paper version (group 10) was printed on a laser printer with Courier 10 font. These modifications were made to place better controls on the presentation modes.

Results

Two research questions were investigated. The questions and respective hypotheses are presented in the order previously stated.

1. Is there a difference in eighth grade students' reading rate on a reading comprehension task among groups performing the task using several different modes of presentation?

To test this first hypotheses, a balanced one way Analysis of Covariance (ANCOVA) statistical procedure was performed using SPSSPC. The reading rate of subjects on the cloze reading task was the dependent variable while the covariate was the normal curve equivalence (NCE) score on the Total Reading subtest of the CTBS. Table 1 presents a summary of descriptive statistics for the CTBS covariate scores. The highest score for the sample test was 99 and the lowest score was 3.

INSERT TABLE 1 ABOUT HERE

Subjects were randomly assigned by the use of a random number table to 10 text presentation groups. The mean reading rate for each group was determined. Table 2 presents the mean and standard deviation for the reading rate of the 10 groups.

INSERT TABLE 2 ABOUT HERE

No statistically significant differences were found at the .05 level in the omnibus hypothesis among the means. Additionally, the effect size was low (4.5%), thus the results were also not educationally significant. Table 3 presents the ANCOVA summary table for reading rate. The null hypothesis was not rejected; therefore, no post hoc tests were performed. This finding contradicts most research studies (Granaas, McKay, Laham, Hurt, & Juola, 1984; Heppner, Anderson, Farstrup, & Weiderman, 1985).

INSERT TABLE 3 ABOUT HERE

When performing a cloze reading exercise, the reading rate of eighth grade students was not statistically or educationally significant when reading from paper or computer. Although no statistical differences were found with the ANCOVAs, students with independent level reading ability did read 27 percent slower from electronic screens than paper.

2. Is there a difference in eighth grade student's comprehension score on the reading comprehension task among groups performing the task using several different modes of presentation?

To test the second null hypothesis, a balanced one way ANCOVA statistical procedure was performed using the comprehension of subjects on the cloze reading task as the dependent variable. The covariate was the normal curve equivalence score (NCE) on the Total Reading subtest of the CTBS. A mean comprehension score was determined for each group. Table 2 presents the descriptive statistics for the comprehension scores.

No statistically significant differences were found among the means on the omnibus hypothesis. Table 4 presents the ANCOVA summary table for comprehension scores. The null hypothesis was not rejected and thus, no post hoc tests were performed.

Students' comprehension scores did not appear to differ for any of the groups tested. This finding was in agreement with the vast majority of previous studies which tested comprehension in various text modes (Feldmann & Fish, 1987a, 1987b, IN PRESS; Gould

et al., 1987; Gould & Grischkowsky, 1984, 1986; Kruk & Muter, 1984; Kak, 1981; Switchenko, 1984).

INSERT TABLE 4 ABOUT HERE

Conclusions

The findings of no differences in reading speed from electronic screens to paper conflicts with most of the findings on adult reading rate research (Gould et al., 1987; Gould et al., IN PRESS; Gould & Grischkowsky, 1984, 1986; Hansen et al., 1978; Hathaway, 1984; Kruk & Muter, 1984). Reasons accounting for the difference in findings may be: (a) the reading of the adult subjects was superior to the eighth grade students; (b) the nature of the reading materials, proofreading as opposed to a cloze passage; and (c) the focus on groups of students rather than the individualized treatment of the adults. This would suggest that reading level might be a factor affecting reading rate from electronic screens or paper.

The finding of no difference in comprehension was consistent with previous studies. Thus, the ability to comprehend text is not necessarily a function of legibility but reading level. The reading rate is affected by legibility. Thus, a reader would reduce his reading rate in order to maintain comprehension.

Summary

Eighth grade students did not read significantly differently from electronic screen or paper. The length of lines or the medium

seemed to make no difference. Thus, for a 30 minute reading task, the medium does not make a marked difference in either the reading rate or comprehension.

More research needs to be performed with school aged children to better identify if different ability groups of students are more or less affected by the presentation mode of text. Research should also be performed to investigate if the reading rate and/or comprehension would deteriorate given longer reading tasks. Finally, other computers besides the IBM PC Junior should be used to determine if particular computers, and the generated font, affect reading rate and/or comprehension.

References

Becker, H. J. (1986). Our national report card: Preliminary results from the New Johns Hopkins Survey. Classroom Computer Learning, 6(4), 30-33.

ChiWriter [Computer program]. (1988). San Jose, CA: Horstmann Software Design.

Daniel, D. B. (1985). The construct of legibility in the reading environment of a microcomputer. (ERIC Document Reproduction Service No. ED 225 908).

Feldmann, S. C., & Fish, M. C. (1987a). A comparison of reading comprehension using print and microcomputer presentation. Journal of Computer-Based Instruction, 14(2), 57-61.

Feldmann, S. C., & Fish, M. C. (1987b). Reading comprehension of high school students on print vs microcomputer-generated text. Paper presented at the Annual Meeting of the American Educational Research Association, Washington, D.C. (ERIC Document Reproduction Service No. ED 282 175).

Feldmann, S. C. & Fish, M. C. (in press). Reading comprehension of elementary, junior high and high school students on print vs microcomputer-generated text. Journal of Educational Computing Research.

Gould, J. D., Alfaro, L., Barnes, V., Finn, R., Grischowsky, N., & Minuto, A. (1987). Reading is slower from CRT displays than from paper: Attempts to isolate a single-variable explanation. Human Factors, 29(3), 269-299.

Gould, J. D., Alfaro, L., Finn, R., Haupt, B., & Minuto, A. (in press). Reading from CRT displays can be as fast as reading from paper. Human Factors.

Gould, J. D., & Grischkowsky, N. (1984). Doing the same work with hard copy and with cathode-ray tube (CRT) computer terminals. Human Factors, 26(3), 323-337.

Gould, J. D., & Grischkowsky, N. (1986). Does visual angle of a line of characters affect reading speed? Human Factors, 28(2), 165-173.

Granaas, M. M., McKay, T. D., Laham, D. Hurt, L. D., & Juola, J. F. (1984). Reading moving text on a CRT screen. Human Factors, 26(1), 97-104.

Griffing, E. J. & Franz, S. I. (1896). On the condition of fatigue in reading. Psychological Review, 3, 513-550.

Hansen, W. J., Doring, R. R., & Whitlock, L. R. (1978). Why an examination was slower on-line than on paper. International Journal of Man-Machine Studies, 10, 507-519.

Hathaway, M. D. (1984). Variables of computer screen display and how they affect learning. Educational Technology, 24(1), 7-11.

Heppner, F. H., Anderson, J. G., Farstrup, A. E., & Weiderman, N. H. (1985). Reading performance on a standardized test is better from print than from computer display. Journal of Reading, 29(1), 321-325.

Hoover, T. (1977). Empirical study of reading and comprehension as a function of CRT display. (ERIC Document Reproduction Service No. ED 161 002).

Huey, E. B. (1968). The psychology and pedagogy of reading. Cambridge, MA: The MIT Press. (Original work published 1908 by the Macmillian Co.).

Kak, A. V. (1981). Relationships between readability of printed and CRT-displayed text [Summary]. Proceedings of the Human Factors Society, 26, 137-140.

Kruk, R. & Muter, P. (1984). Reading of continuous text on video screens. Human Factors, 26(3), 339-345.

Muter, P., Latremouille, S. A., Treurniet, W. C., & Beam, P. (1982). Extended reading of continuous text on television screens. Human Factors, 24(5), 501-508.

Niman, J. (1987). Precollege mathematics software: Limitations and potential. In J. Moonen and T. Plomp (Eds.), Eurit 86 developments in educational software and courseware (pp. 55-65). Oxford: Pergamon Press.

Sanford, E. C. (1888). The relative legibility of the small letters. American Journal of Psychology, 1, 402-435.

Switchenko, D. M. (1984). Reading from CRT versus paper: The CRT-disadvantage hypothesis re-examined [Summary]. Proceedings of the Human Factors Society, 28, 429-430.

Tinker, M. A., (1963). Legibility of print. Ames, IA: Iowa State University.

Table 1

Means and Standard Deviations for CTBS Total Reading NCEs by Group

Group	Mean	SD
1	45.63	19.70
2	56.93	21.46
3	55.03	17.73
4	52.40	17.39
5	55.13	23.88
6	55.77	19.10
7	57.50	22.33
8	52.23	21.99
9	49.70	18.68
10	51.47	23.10
Total	54.08	20.48

Note. Each group contained an N of 30.

Table 2

Descriptive Statistics by Group on Reading Rate and Comprehension

Group	Reading Rate		Comprehension	
	Mean	SD	Mean	SD
1	12.28	3.84	49.80	9.00
2	14.10	5.57	50.40	8.43
3	13.36	4.34	50.87	8.55
4	13.13	3.30	45.53	7.25
5	12.90	3.66	50.73	7.17
6	12.16	4.03	48.53	9.67
7	13.86	5.30	48.47	9.77
8	13.02	3.68	46.80	12.29
9	11.96	4.05	50.13	8.40
10	12.78	6.05	48.13	10.53
Total	12.96	4.45	48.94	9.28

Note. Reading rate was measured in minutes.
Note. Each group contained an N of 30.

Table 3

ANCOVA Summary Table for the Effect of Text Mode Presentation on Reading Rate

Source	SS	df	MS	F	r^2
Covariate NCE	1154.78	1	1154.78	72.96	.195
Main Effect Group	205.31	9	22.81	1.44	.035
Residual	4574.27	289	15.83		

Table 4

ANCOVA Summary Table for the Effect of Text Mode Presentation on Comprehension

Source	SS	df	MS	F	r^2
Covariate NCE	10441.34	1	10441.34	207.37	.416
Main Effect Group	78.10	9	8.68	.17	.003
Residual	14551.49	289	50.35		